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MONTHLY NOTICES
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Letter to the Hon. R. W. Thompson, Secretary of the Navy, announcing the Discovery of Satellites of Mars.

U.S. NAVAL OBSERVATORY, WASHINGTON,
August 21, 1877.

SIR,—The outer satellite of *Mars* was first observed by Professor Asaph Hall, U.S.N., on the night of August 11, 1877. Cloudy weather prevented the certain recognition of its true character at that time. On August 16 it was again observed, and its motion was established by observation extending through an interval of two hours, during which the planet moved over thirty seconds of arc.

The inner satellite was first observed on the night of August 17, and was also discovered by Professor Hall.

On Saturday, August 18, the discoveries were telegraphed to Alvan Clark & Sons, Cambridgeport, Mass., in order that if the weather should be cloudy at Washington, they might confirm the existence of the satellites with the 26-inch telescope of Mr. McCormick, which is in their hands.

This discovery was confirmed by Professor Pickering and his assistants, at Cambridge, Mass., and by the Messrs. Clark, at Cambridgeport.

On August 19, the discovery was communicated to the Smithsonian Institution, by which it was announced to the American and European observatories in the following despatch :—

Two satellites of Mars discovered by Hall, at Washington. First, elongation west, August 18, *eleven hours, Washington time. Distance, eighty seconds. Period, thirty hours. Distance of second, fifty seconds.*

It will be seen hereafter that the statement of fifty seconds as the distance of the inner one was erroneous.

The observations hitherto made are as follow :—

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The First Satellite.

	h m	°	h m	″	Observer.
877, Aug. 11,	14 40,	$p =$ 59·6 (2);	14 45,	$s =$ 70·57 (2)	Hall.
16,	11 42,	. . . . .	.	$s =$ 77·6 (1)	Hall.
	13 7,	$p =$ 71·9 (2);	.	$s =$ 80·83 (4)	Hall.
	13 36,	. . . . .	.	$s =$ 80·4 (1)	Hall.
17,	16 2,	$p =$ 85·5 (2);	16 19,	$s =$ 63·24 (3)	Hall.
18,	10 28,	$p =$ 251·7 (3);	10 18,	$s =$ 82·93 (8)	Newcomb.
	10 57,	$p =$ 244·5 (1);	11 5,	$s =$ 81·6 (1)	Harkness.
	11 50,	$p =$ 246·6 (4);	11 57,	$s =$ 81·77 (4)	Hall.
	14 32,	$p =$ 232·1 (4);	14 39,	$s =$ 61·04 (4)	Hall.
19,	11 42,	$p =$ 283·2 (2);	11 49,	$s =$ 46·20 (4)	Hall.
	15 43,	$p =$ 255·4 (4);	15 52,	$s =$ 81·37 (6)	Hall.
20,	10 28,	$p =$ 61·1 (3);	10 33,	$s =$ 76·07 (2)	Hall.
	11 57,	$p =$ 52·1 (4);	12 7,	$s =$ 59·93 (4)	Hall.

The Second Satellite.

1877, Aug. 17,	16 6,	$p =$ 73·0 (2);	16 21,	$s =$ 30·81 (4)	Hall.
18,	11 31,	$p =$ 248·8 (2);	11 37,	$s =$ 34·65 (4)	Hall.
19,	11 25,	$p =$ 226·8 (2);	11 30,	$s =$ 24·08 (2)	Hall.
20,	13 15,	$p =$ 67·1 (1);	13 26,	$s =$ 31·95 (3)	Hall.
	13 56,	. . . . .	.	$s =$ 27·02 (4)	Hall.
	14 22,	$p =$ 70 (est.);	14 22,	$s =$ 19·16 (3)	Hall.
	16 19,	$p =$ 250 (est.);	16 19,	$s =$ 15·15 (7)	Hall.
	16 35,	. . . . .	.	$s =$ 16·70 (7)	Hall.

From these observations Professor Newcomb has derived the following approximate circular elements of the orbits. The probable errors assigned are only very rough estimates.

The Outer Satellite.

Major semi-axis of apparent orbit seen at distance [9·5930]	82″·5 ± 0″·5
Minor semi-axis of apparent orbit seen at distance [9·5930]	27″·7 ± 2″.
Major semi-axis of orbit seen at distance unity	32″·3
Position-angles of apsides of apparent orbit	70°, 250° ± 2°
Passage through the west apsis ($p = 250°$), Aug. 19, $16^{h}{\cdot}6$, W.M.T.	
Period of revolution	$30^{h}\ 14^{m} \pm 2^{m}$
Hourly motion in Areocentric longitude	11°·907
Inclination of true orbit to the ecliptic	25°·4 ± 2
Longitude of ascending node	82°·8 ± 3

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Position of pole of orbit in celestial sphere .	Long.	352·8
	Lat.	+ 64·6
	R.A.	316·1
	Decl.	+ 53·8

These elements give for the Mass of *Mars* . $\frac{1}{3{,}090{,}000}$

The Inner Satellite.

Major semi-axis of apparent orbit at distance [9·5930] . 33″·0 ± 1″

Period of revolution . . . . $7^{\text{h}}\ 38^{\text{m}}{\cdot}5 \pm 0^{\text{m}}{\cdot}5$

Hourly motion in Areocentric longitude . . . . . 47°·11

Passage through the eastern apsis ($p = 70°$) Aug. 20, $13^{\text{h}}{\cdot}0$, W.M.T.

Very respectfully, your obedient servant,
John Rodgers,
Rear Admiral and Superintendent.

The Hon. R. W. Thompson, Secretary of the Navy.

On the Solution of Kepler's Problem.

By J. W. L. Glaisher, M.A., F.R.S.

§ 1. Writing Kepler's equation in the form

$$x = a + e \sin x, \qquad (1)$$

the solution in powers of e is

$$x = a + e\sin a + \frac{e^2}{1.2}\frac{d}{da}(\sin^2 a) + \frac{e^3}{1.2.3}\frac{d^2}{da^2}(\sin^3 a) + \&c.,$$

and, on performing the differentiations, it will be found that

$$\begin{aligned}
x = {} & a \\
& + e.\sin a \\
& + e^2.\sin a\cos a \\
& + e^3.\sin a\cos^2 a - \frac{1}{2}\sin^3 a \\
& + e^4.\sin a\cos^3 a - \frac{5}{3}\sin^3 a\cos a \\
& + e^5.\sin a\cos^4 a - \frac{11}{3}\sin^3 a\cos^2 a + \frac{13}{24}\sin^5 a \\
& + e^6.\sin a\cos^5 a - \frac{20}{3}\sin^3 a\cos^3 a + \frac{47}{15}\sin^5 a\cos a \\
& + e^7.\sin a\cos^6 a - \frac{65}{6}\sin^3 a\cos^4 a + \frac{1291}{120}\sin^5 a\cos^2 a - \frac{541}{720}\sin^7 a \\
& + e^8.\sin a\cos^7 a - \frac{49}{3}\sin^3 a\cos^5 a + \frac{427}{15}\sin^5 a\cos^3 a - \frac{1957}{315}\sin^7 a\cos a \\
& + \&c. \qquad (2)
\end{aligned}$$